I-ImaS

CTI:

Update on remaining issues regarding
Image Analysis and Controller Logic

London, 22 – 23 Nov 2006

Remaining Issues on Image Analysis and Control:

- Image Restoration & Pre-processing Filters Design
- Adaptive Control for Image Quality / Dose / Clinical optimality
- System Calibration Resources & Procedures

Aspects of imaging / control-related experiments:

- Flat-field correction (no target object)
- Image Quality: Technical (test-pattern target)
- Image Quality: Clinical (tissue-mimicking phantom)

Note: Dose measurements are included in "Image Quality" tests

Experiments (1): Flat-field correction

- Goal is to measure all non-uniformities at sensor plane
- Only system's internal statistics are addressed here
- Experiments conducted with no target object at all
- Image set: all scout beam & wedge filter settings

Addresses problems related to:

- Bad pixels / "salt & pepper" noise
- Cumulative statistical noise at pixel-level
- Non-uniform gain & dose/absorption profile *(*)*

(*): Tissue-mimicking phantom is required for absorption estimation

Experiments (2): Image Quality / Technical

- Goal is to measure all non-uniformities during scanning
- Only system's internal statistics are addressed here
- Experiments conducted with test-pattern (geometric)
- Image set: all scout beam & wedge filter settings

Addresses problems related to:

- Multi-sensor alignments (vertical)
- PSF spreading due to line-scanning movements (if any)
- *Perspective distortions due to conical projection (*)*

(*): Only for post-processing, requires multi-angle projections

Experiments (3): Image Quality / Clinical

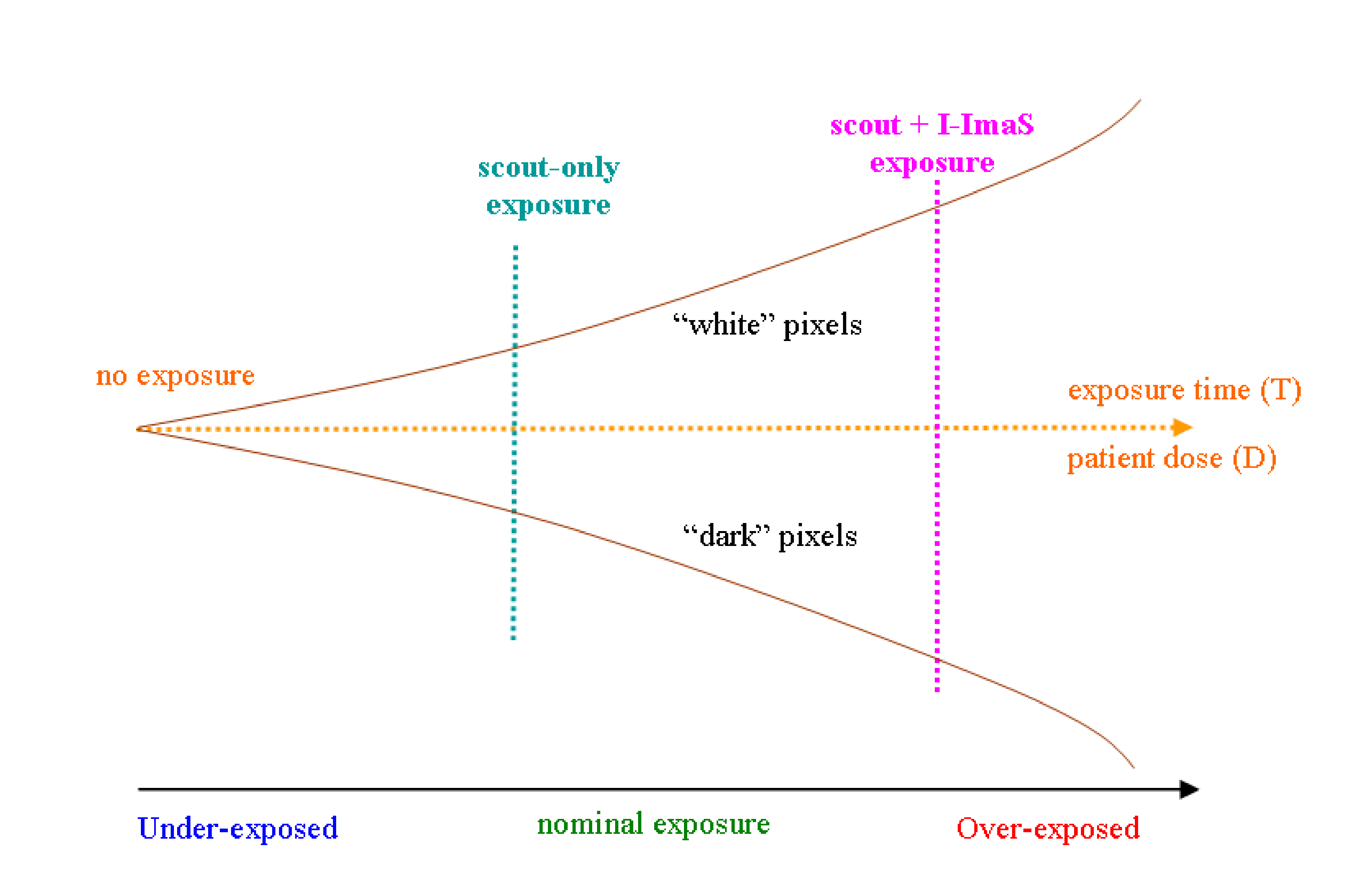
- Goal is to introduce experts' knowledge into the control
- Application-specific, requires analytical evaluation
- Experiments conducted with tissue-mimicking phantoms
- Image set: all scout beam & wedge filter settings

Provides the means to:

- Make the controller more "intelligent" than on/off trigger
- Must include skin dose estimation (real or calculated)
- Expert's preference "mapped" to textural features *(*)*

(*): Quality Index (QI) as linear regression of a set of features

Image normalization: Dynamic range estimation during scanning



Example of ORP: Expert's evaluation against beam settings

I-ImaS setup: acceptable dose, high quality

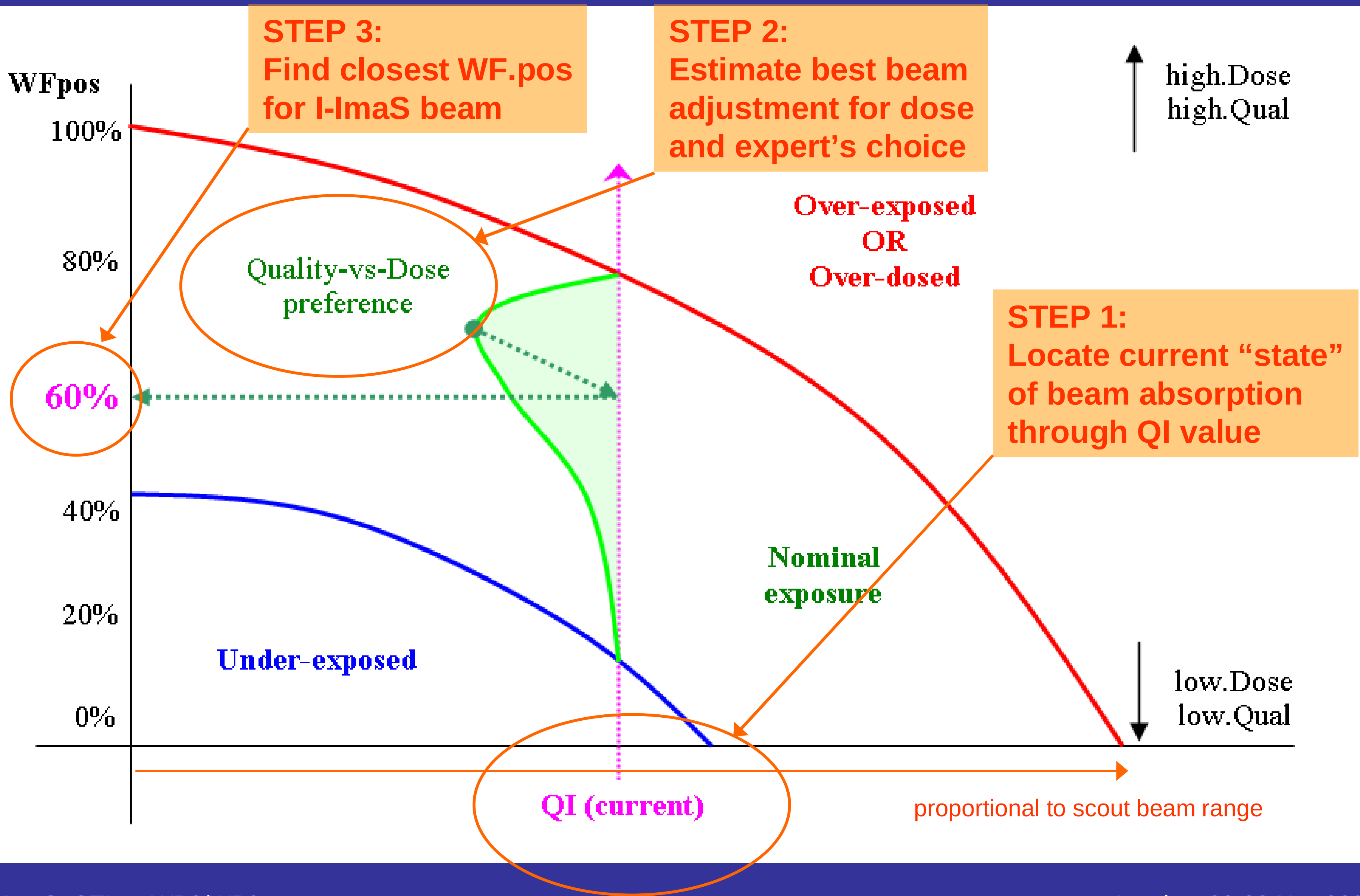
Expert's Evaluation Table on Scout Scan Images
value.QI: <70 (underE), >100 (overE)

WF.pos: 100%	93	99	108	117	120
WF.pos: 80%	84	87	102	110	113
WF.pos: 60%	77	81	99	104	107
WF.pos: 40%	70	75	89	98	104
WF.pos: 20%	62	69	77	93	100
WF.pos: 0%	53	61	69	89	99
	Scout beam level: 30%	Scout beam level: 35%	Scout beam level: 40%	Scout beam level: 45%	Scout beam level: 50%

I-ImaS setup: low dose, acceptable quality

Note: Tests at multiple scout beam levels are necessary to cover all possible cases of tissue-related areas during normal operation.

Example of OCP: From texture analysis to I-ImaS beam adjustments



Design of the desired system response:

Summary of I-ImaS Models for On-Line Control	**Reactive Control** (error-based)	**Reactive Control** (error-based)	**Reactive Control** (error-based)	**Anticipatory Control** (predictive)
	Simplistic "blind" optimization stationary	**Fully-Adaptive** "blind" optimization non-stationary	**Model-Matching** Use experts' "reference" points	**Model-Matching** Use experts' "reference" points
Direct Single-step analytical solution	**FG/BG Percentile Model** (SINTEF) tested/verified *(see: report D.9)*	**Weighted Linear Model** (CTI/UoT) adaptive limits and quality/dose tpl.	**Weighted Linear Model** gain-directed *(see: report D.9)*	**Weighted Linear Model** gain-directed *(see: Trieste/06)*
Iterative Multi-step analytical solution	*Small-step adjustments (?)*	*Gradient-based algorithms (?)*	*Gain-directed gradient-based algorithms (?)*	*Gain-directed gradient-based algorithms (?)*
Heuristic Behavioral model (on-line learning)	---	---	**Reinforcement Learning Model** error-based *(see: Trieste/06)*	**Reinforcement Learning Model** predictive *(see: Trieste/06)*

selected design framework for I-ImaS launch

Remaining phases of work for I-ImaS "intelligence":

Images from I-ImaS sensors | Dose Measurements

Statistical Analysis | Evaluation from Experts

Required Pre-Processing | Texture-to-Quality LInear Model | Combined Index (Quality+Dose)

Calibration Protocols | OOP | OCP | ORP

Final I-ImaS Image Analysis | Final I-ImaS Adaptive Control

Suggestive References:

[23] *I-ImaS, Workpackage 3 – Deliverable D.8*, "Translating information signatures to a sequence of well-defined processing functions", Feb.2005

[24] *I-ImaS, Workpackage 3*, "Update on current progress and report for deliverable D.8", CTI presentation for 3rd I-ImaS meeting, London, 12-13 Oct 2004

[25] *I-ImaS, Workpackage 3 – Deliverable D.9*, "Different approaches to providing intelligence to the sensor/imaging system", Mar.2005

[26] *I-ImaS, Workpackage 3*, "Update on current progress and deliverable report D.8", CTI presentation for 4th I-ImaS meeting, Oslo, 14-15 Feb 2005

[29] *I-ImaS, CTI*, "Top-level system designs", Mar.2005

[34] *I-ImaS*, "Enhancements to the image pre-filtering and image restoration options, and preface to x-ray camera geometry", CTI presentation for 5th I-ImaS meeting, Athens, 29-30 Sept 2005.

[35] *I-ImaS*, "Improved Adaptive Control by Anticipatory and Reinforcement-Learning options for the I-ImaS Controller Logic", CTI presentation for 6th I-ImaS meeting, Trieste, 10-11 Jan 2006.

[36] *I-ImaS*, "Summary of patent-related issues regarding Image Analysis and Controller Logic", CTI presentation for 7th I-ImaS meeting, Ioannina, 23-24 May 2006.